State of Illinois
Rod R. Blagojevich, Governor

Illinois Emergency Management Agency
e, Director

INFO: How a Boiling Water Reactor Works

Seven of the 11 nuclear power reactors currently operating in Illinois are Boiling Water Reactors (BWRs). The other kind of power reactor in Illinois is called a Pressurized Water Reactor (PWR). While the details differ from those presented here, the overall process in a PWR is the same: the reactor fuel generates enough heat to boil water, which produces steam, which is used to drive a turbine/generator, which generates electricity.

While the Illinois Emergency Management Agency (IEMA) - Bureau of Nuclear Facility Safety does not regulate nuclear power stations, it does monitor each reactor through its Remote Monitoring System (RMS) in order to be ready in case an accident does occur. In addition, the department has a Resident Inspector at each station who inspects safety systems in cooperation with federal inspectors. For more information, see our *Info: Agency Inspectors at Nuclear Power Stations*.

In this publication, features of a BWR in **bold type** are illustrated in the cutaway drawing on the front page. Terms in *italic type* are found in the schematic diagram inside. Terms in ***bold italic type*** are found in both. Capitalized terms are not shown in the illustrations.

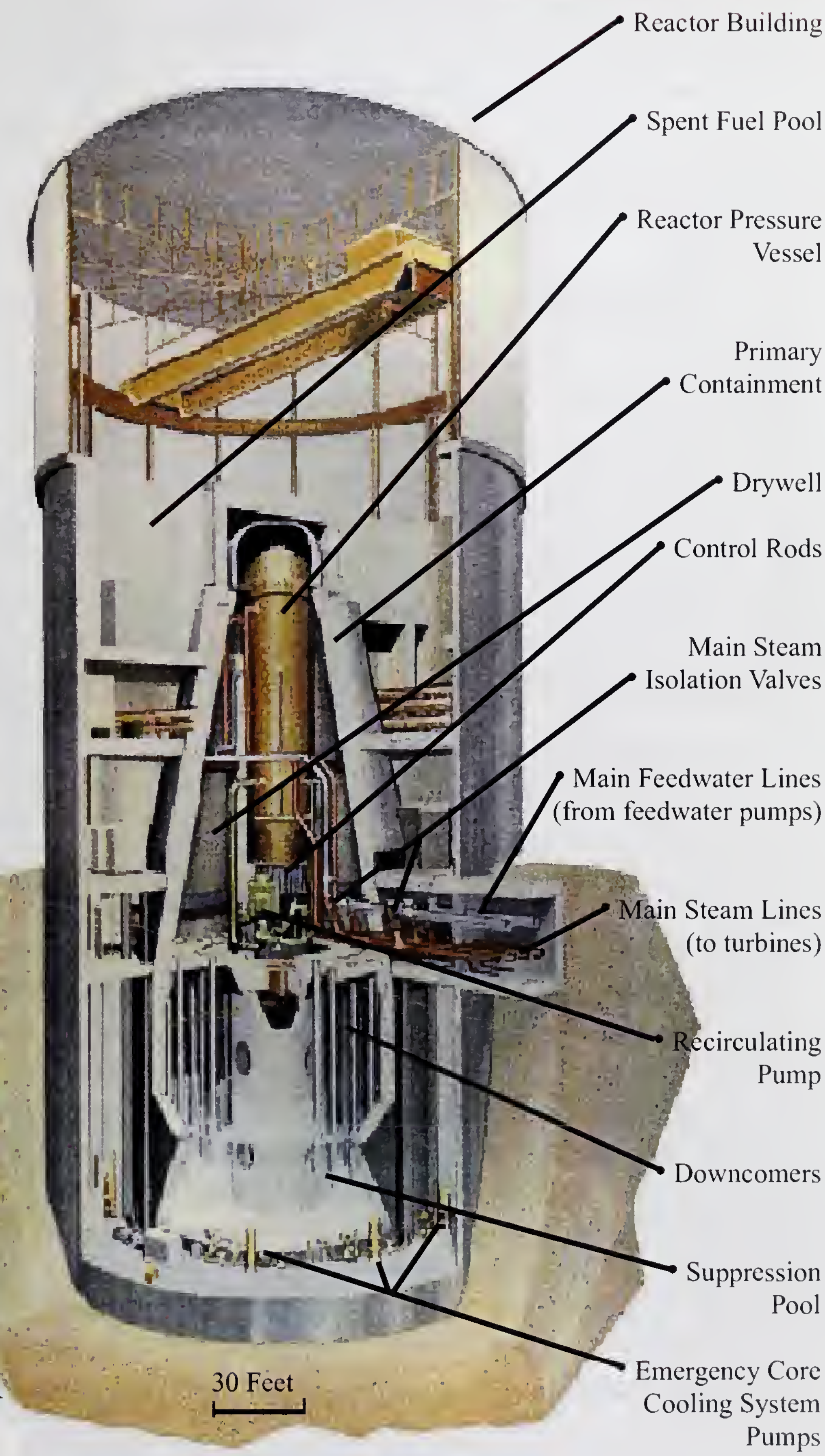


Figure 1. Cutaway diagram of a typical BWR

The Nuclear Core

Nuclear power reactors generate electricity. While most power plants burn coal, natural gas or petroleum to create steam, nuclear reactors use an element called uranium instead of fossil fuel and produce heat by a process called fission. Fission occurs when an atom is hit by a neutron, which is a component of the nucleus of an atom. Each atom that splits creates heat and releases more neutrons, which hit other atoms, causing them to split, and so on, in a "chain reaction."

The fission process takes place within uranium fuel pellets, which are held in long Fuel Rods. Bundles of fuel rods are called Fuel Assemblies. Each reactor core contains about 700 fuel assemblies.

Reactor power—how much steam the reactor is creating, and thus, how much electricity is being generated—is controlled using ***Control Rods*** and the ***Recirculation System.*** Control rods are made of a special material that captures neutrons to prevent them from splitting the uranium atoms.

When the power level in the core is greater than 15 percent, the *Main Generator Breaker* is closed, connecting the generator to the electrical power *Grid*, which supplies power to industry, businesses and homes.

The Steam Cycle

A BWR uses nuclear fission to directly produce steam to turn a turbine-generator to produce electricity. Inside the ***Reactor Pressure Vessel***, the fission process in the *Reactor Core* produces heat, which boils water to produce steam.

After passing through *Moisture Separators* and *Dryers*, the dry steam is delivered to the *Turbine-Generator* through the ***Main Steam Lines***. Dual ***Isolation Valves*** in each of the four steam lines just inside and outside of the ***Primary Containment*** ensure that any potential radioactive releases to the public are prevented or kept below federal limits.

The steam then enters the *High Pressure Turbine*, passes through the *Moisture Separators/Reheaters* and enters the *Low Pressure Turbines*. The turbines turn the *Generator*, which produces the electricity. The Main Transformer connects the main generator to the electrical transmission grid. The System Auxiliary Transformer brings power onto site whenever the reactor is not producing electricity. In conjunction with the Unit Auxiliary Transformer, it also supplies plant electrical power during reactor operations.

The steam leaves the low pressure turbines and is condensed back into water in the *Condenser* by the *Circulating Water System*. The *Condensate* pumps take water from the condenser *Hotwell* and pump it through the *Condensate Filter/Demineralizers*, where impurities are removed.

The *Condensate Booster Pumps* then pump the water through a series of *Low Pressure Heaters*, which use turbine steam to preheat the water before it returns to the reactor vessel. The *Feedwater Pumps* send the water through the *High Pressure Heaters* for additional pre-heating (again using turbine steam) and then into the reactor vessel at high pressure through the ***Main Feedwater Lines***, completing the cycle.

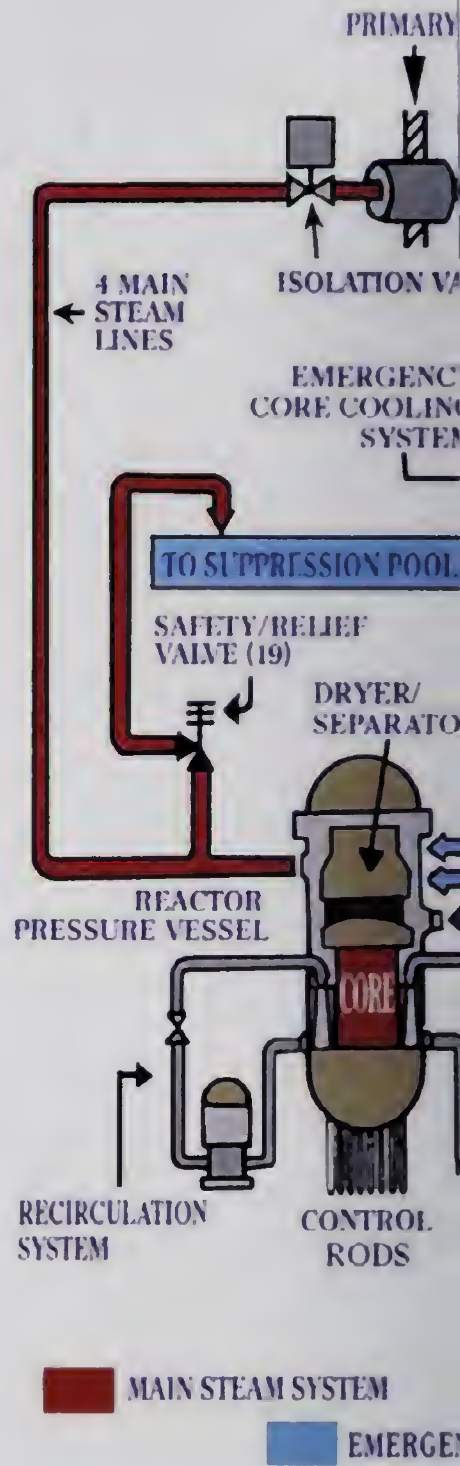
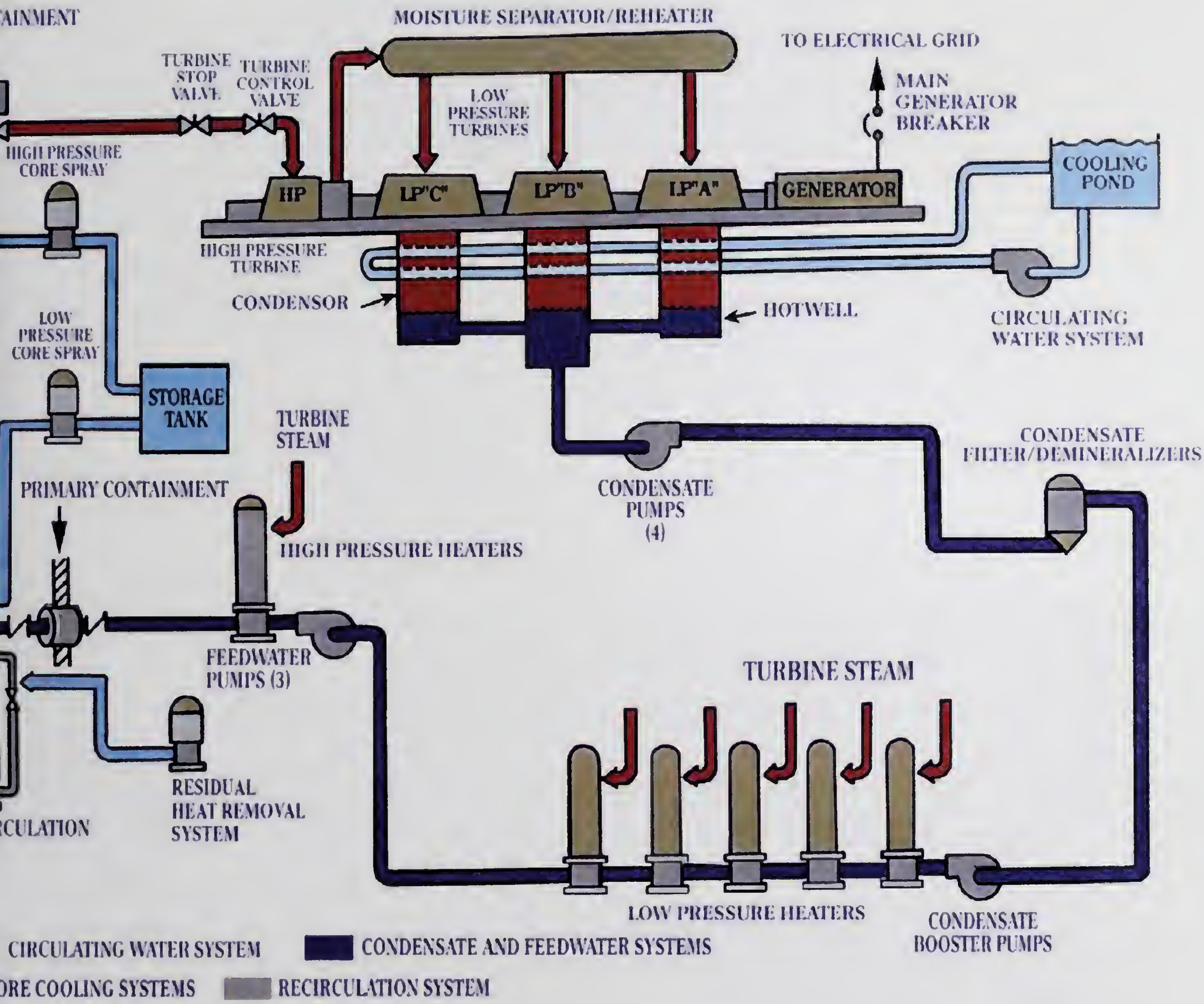


Figure 2. Schematic Diagra

Reactor Safety Systems

Controls for the nuclear reactor, the steam system and safety systems are on Control Panels in the Control Room, where reactor operators licensed by the federal Nuclear Regulatory Commission



a BWR.

monitor and operate the plant's systems. The IEMA-Bureau of Nuclear Facility Safety is connected to the control room computer through the RMS. This connection allows agency staff to monitor conditions within the plant during an accident, and use that information to make recommendations on protective actions for the public.

Should an abnormal condition occur, the control rods can be rapidly inserted (a SCRAM) to shut down the fission process. A scram may be automatic or manual.

A nuclear reactor differs from conventional power plants in that the core continues to generate heat even when the control rods are fully inserted, although at a far lower rate. This heat is caused by other radioactive elements that are created through the fission process. Long-term cooling to remove this "decay" heat is provided by the *Residual Heat Removal System.*

Additional systems are available to supply cooling water and reduce the effects of an accident. These ***Emergency Core Cooling Systems*** are the *High Pressure Core Spray*, the *Low Pressure Core Spray* and the *Residual Heat Removal*

System. During normal operations, the *Safety/Relief Valves*, located on the main steam lines, relieve excess pressure in the steam system during an accident, and can quickly reduce the pressure inside the reactor pressure vessel. Steam released by these valves is directed into the ***Suppression Pool***, where it is condensed.

Emergency Diesel Generators ensure electrical power is available to the plant at all times. The Standby Gas Treatment System, an emergency ventilation system, is used to minimize radioactive releases. These systems automatically start based on plant conditions, or can be manually started. With the exception of the emergency diesels, they are all located in the **Reactor Building**.

Release Prevention Barriers

There are three designed barriers to prevent a radiological release to the public. The first barrier is the Clad, the metal tubing that surrounds the fuel pellets that make up a fuel rod.

The second barrier is the pressure boundary in a boiling water reactor. This includes the reactor pressure vessel and the main steam and recirculation systems.

The third release barrier is the ***Primary Containment*** structure. The containment is a reinforced concrete structure, in places six feet thick. It consists of the **Drywell** and the suppression pool. Leaks from the plant systems into the drywell are directed into the suppression pool through the **Downcomers**, where it is condensed. This reduces the pressure, keeping it below the containment's design limits, and thus limiting any possible radioactive release.

Should a release be necessary, after filtering and processing to reduce the amount of radioactivity, it will be released through the station Ventilation Stack. In addition to the in-plant monitoring systems, IEMA's RMS is designed to independently detect any releases from the plant.

Fuel Cycle

Every 18 to 24 months the reactor is refueled. About one-third of the fuel assemblies are replaced with new fuel. The New Fuel Storage Vault stores new fuel assemblies prior to use in the reactor core.

Fuel assemblies no longer used in the reactor core are transferred from the reactor vessel to the **Spent Fuel Pool** or Independent Spent Fuel Storage Installation (ISFSI) for long-term storage. Dedicated cooling systems are available for long-term spent fuel cooling.

For more information, please contact:

IEMA-Bureau of Nuclear Facility Safety
1035 Outer Park Drive • Springfield, Illinois 62704
217/785-9900 • TDD: 217/782-6133
www.state.il.us/iema

Printed by the Authority of the State of Illinois
IIS GRAPHICS 2006 **(IISG1040-200-6/06)**
P.O. #180

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